ENERGY EFFICIENT LOAD BALANCING WITH ADAPTIVE CLUSTERING IN WIRELESS SENSOR NETWORKS

SHORT SYNOPSIS

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by

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Certificate

I hereby declare that the short synopsis "Energy Efficient Load Balancing with Adaptive Clustering in Wireless Sensor Networks" is being submitted in partial fulfillment of the requirement for the degree of Doctor of Philosophy in Electronics and Communication under Faculty of Engineering and Technology of Manav Rachna International Institute of Research & Studies, Faridabad during the academic year 2021-2022.

It is a bonafide record of original work carried out under the supervision of Dr. Abhiruchi Passi and has not been submitted in full or part to any other university or institute for degree or diploma. Further, it is certified that short synopsis is plagiarism free and proof has been submitted.

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ABSTRACT

Wireless sensor networks (WSN) are increasingly finding their way in diverse applications be it the realization of IoT or real-time monitoring of the environment, health, defense, and even domestic ones. A wireless sensor network consists of a large number of small self-configurable sensor nodes that are capable of performing functions of sensing, processing, and communication of information. Sensor nodes are inherently constrained in terms of energy, computational and communicational capabilities. Most of the sensor nodes are battery-powered with a limited supply of energy. The battery of a sensor node is hard/ impossible to be replaced once deployed. Lifetime of a wireless sensor node or sensor network is concerned with energy and energy is strictly constrained. Most of the energy of a sensor node is consumed during communication, therefore; energy efficiency should be the prime focus while designing the hardware and software of wireless sensor networks. A survey of various algorithms concerned with the lifetime enhancement of a wireless sensor network was carried and gaps have been found. To accomplish these gaps new or modified algorithms will be investigated and an energy-efficient algorithm for extending the lifetime of a wireless sensor network will be explored with quality of service under consideration i.e. will try to establish a trade-off between energy efficiency and quality of service.

Keywords: Wireless sensor Networks (WSN), lifetime maximization, Adaptive clustering, load balancing, quality of service.

CONTENTS

1.	**Introduction**		**01-03**
	1.1.	Introduction	01
	1.2.	Applications and challenges in WSN	03
2.	**Literature Review**		**04-08**
	2.1.	Gaps in Literature	08
3.	**Description of Topic**		**08-12**
	3.1.	Clustering	09
	3.1.1.	Components of a cluster	09
	3.1.2.	Performance metrics of cluster based WSN	10
	3.1.3.	Advantages in clustering	11
	3.1.4.	Challenges in clustering	12
	3.2.	Load balancing in wireless Sensor Networks	12
4.	**Objectives of Research**		**12-13**
	4.1.	Problem Formulation	12
	4.2.	Objectives of Research	13
5.	**Methodology**		**14**
6.	**Expected outcomes**		**15**
7.	**Proposed Time Plan**		**16**
8.	**References**		**16-20**

1. INTRODUCTON

In the past few years, wireless sensor networks have seen a huge growth in terms of both technology as well as applications. Wireless sensor networks (WSN) are cheap, small in size and often with little or no underlying infrastructure (Mishra and Paul 2017). WSNs consist of a large number of small sized sensor nodes that are randomly deployed in an area of interest. A sensor node is responsible for collection of data, information processing and communicating that data for further processing, analysis and storage (Mamalis *et al.* 2009). Hence, in a WSN a sensor node does not only have a sensing unit but also it consists of a processing, storage and a communicating unit as well. A small battery usually powers a wireless sensor node with a limited capacity and in most of the cases, it is nearly impossible to replace that once exhausted (Gupta and Kumar 2013). A sensor node that performs these multiple functions of data collection, processing, storage and communication is referred to as a *mote*. A mote can be equipped with a multiple number of sensors for different applications like physical measurements (Temperature, light, humidity, and pressure), motion detection, noise levels, mechanical stress, etc. In a wireless sensor network, nodes posses some unique constraints, that are different from other wireless networks. They have limited computational (processing and storage) and communicational capabilities.

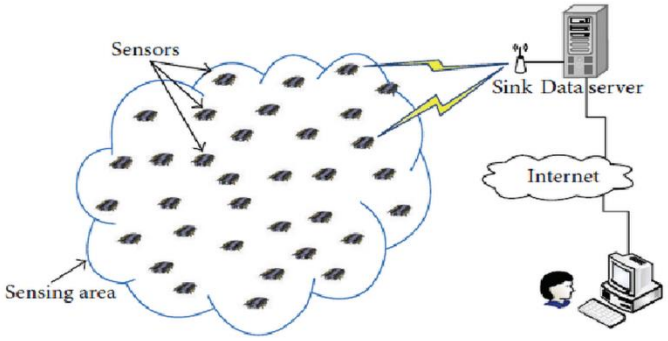

Figure 1: Wireless Sensor Network (Rao *et al* 2015).

M. A. Matin (2012) defines Wireless sensor network as, "Wireless Sensor Networks (WSNs) can be defined as a *self-configured* and *infrastructure-less* wireless networks to monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants

and to cooperatively pass their data through the network to a main location or sink where the data can be observed and analyzed."

In a WSN various nodes communicate with each other using the IEEE 802.15.4 standard for wireless communication. Depending upon the network topology, the communication takes place either in a single hop or there is multi-hop communication. Usually a group of sensors communicate their sensed data to a common node called sink, that aggregates the data and sends it to the destination using a backhaul network.

A wireless sensor node mainly consists of five units: Processing unit, storage unit, Communication unit, Sensing unit and power supply unit.

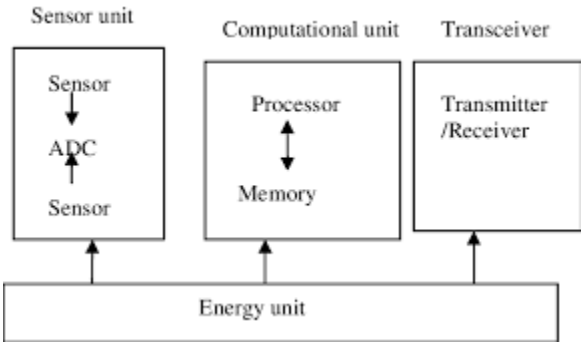

Figure 2: Architecture of a wireless sensor node (Maraiya, Kant and Gupta 2011)

i. Controller: A controller to perform the computation and necessary process sing of the information

ii. Memory: It is used to store the data and intermediate results. There is separate memory for data and program code.

iii. Sensors and actuators: A wireless sensor node may be equipped with one or more sensors to gather the required data from the surroundings. After computation and processing of data actuators act according to the instructions.

iv. Communication: For exchange of information involving transmission and reception of data, a sensor node is equipped with a communication module.

v. Power supply: Usually no tethered power supply is available, small exhaustible battery/ies power a wireless sensor node. However, advanced techniques of energy harvesting are nowadays available. (e.g., solar cells, thermal, wind and hybrid model of energy harvesting).

1.2. Applications and Challenges of Wireless Sensor Networks:

WSNs are often used for low-power and low-data rate applications owing to the constraints of limited energy, bandwidth and communication capabilities. WSN are being used in various fields ranging from military to domestic ones. In military applications WSNs can be used for surveillance, object tracking or can be deployed in and around important sites like nuclear plants, telecom centers or oil and gas plants for protection. Besides they are used for emergency and disaster prediction, health monitoring and in smart home applications (Madhuri, Umar and Veeraveni 2013).

Unlike a centralized system, a wireless sensor network is subject to a set of unique constraints such as finite power supply (typically a battery), limited computational and communicational capabilities. Following are some main challenges faced by Wireless sensor networks:

1. Limited Energy Capacity: Energy source in a Sensor node is a battery, is thus exhaustible. Therefore, energy efficiency should be prime focus while designing a wireless sensor network.
2. Limited Hardware Resources: Sensor nodes are equipped with a microcontroller having low processing speed and a relatively small storage capacity. These nodes are meant to perform only some limited computational tasks.
3. Scalability: A wireless sensor network (WSN) should be scalable i.e. extension or reduction of the network should not affect its functionalities.
4. Fault tolerance: A WSN should have the ability to withstand problems like node failure due to their deployments. A WSN should be self- repairing and self-recovering.
5. Reliability: In some applications, error free delivery of data is essential like military and critical care applications. WSN's should ensure that data be reliably delivered by making use of error detection and correction mechanisms.
6. Massive and Random Deployment: Wireless sensor network, consists of large number of sensor nodes (100's to 1000's) deployed in a random fashion in harsh and hostile environment. After deployment, sensor nodes need to organize themselves into an operational network.
7. Dynamic and Unreliable Environment: A wireless sensor network possesses dynamic network characteristics due to frequent topological changes owing to node failures due to

damage or depletion of energy or addition or migration of nodes. In addition to it, the wireless medium can be noisy, time varying and unreliable.

8. Muliple Applications: Wireless Sensor networks have numerous applications giving rise to different requirements. As such, designing of a wireless sensor network is highly application specific and no universal protocols are applicable.
9. Security: Many wireless sensor networks collect sensitive information.
10. Channel utilization: Communication bandwidth available to WSNs is very limited, therefore routing protocols should make efficient use of it.

2. LITERATURE REVIEW

Wireless sensor networks are used for variety of application ranging from military to domestic one and such a diverse range of applications gives rise to various challenges that are different from traditional wireless network systems. Wireless sensor networks are inherently constrained in terms of energy, computational capability and communicational capacity. Lifetime of a wireless sensor network depends upon the available energy. For extending the lifetime of wireless sensor network several algorithms have been proposed based on efficient utilization of energy. Many have discussed about load balancing and clustering as a solution for energy optimization along with maintaining the quality of service as per requirement. A detailed review of literature is done regarding these two techniques.

Gupta, V. and Pandey, R. (2016) have proposed an improved version of Energy efficient Distributed unequal Clustering (EEDUC) Protocol by considering a weight function based on the residual energy of the cluster heads and distance from the base station for adaptive clustering. One of the main objectives of the proposed technique is to address the energy-hole problem is cluster based wireless sensor networks. The cluster size being adaptive and function of distance from the base station, residual energy of the node and number of neighbors results in higher energy efficiency and there by extending the network lifetime in contrast to other protocols under comparison. In addition, once clustering is done it remains fixed for certain number of rounds in order to reduce the clustering overhead.

A.M. and Paulus, R. (2016) have proposed an Energy and Interference Aware Multipath Routing Protocol for Load Balancing in WSN. A routing protocol with multipath transmission depending

upon a cost function based on residual energy and interference metrics is proposed. In addition to it, the algorithm tries to improve the lifetime of the network by applying load balancing based on energy, delay and bandwidth between the source and destination node.

Jan, B. *et al.* (2017) have presented a detailed review on clustering in wireless Sensor Networks. Different clustering parameters are characteristics have been discussed. It has also presented a detailed report on various clustering algorithm highlighting the proposed techniques, achievements and the open issues for further research.

Avvannavar, J. and Student, M. T. (2017) have proposed a decentralized algorithm called Game Theoretic Energy Balance Routing Protocol in order to extend the network lifetime by employing Geographical Routing Protocols (GRPs) to balance the energy consumption. The region surrounding the source node is divided into k sub-regions, Evolutionary Game theory (EGT) is used to select the appropriate sub-region, and to select the best forwarding node from that sub-region Classical Game Theory (CGT) is employed. The combination of these three protocols has proven to be effective in extending the lifetime of the network. However, the nodes need to be equipped with the positioning hardware or be deployed at prefixed locations only.

Chien, C. and Wang, M. (2017) have proposed an energy efficient load balancing algorithm for Clustering in WSN with adaptive cluster size. An attempt has been made to optimize the energy consumption in wireless sensor nodes. The optimization function is based on the distance between the cluster heads and the base station; greater the distance smaller is the cluster size and hence lesser are the number of neighbors of a cluster head. Results have shown that in addition to improvement in network lifetime the stability also improved; the time duration from the death of first node to the death of the network is shortest among other algorithms under consideration.

Yousif, Y. K. *et al.* (2018) have proposed an Energy Efficient routing protocol for wireless sensor networks based on load balancing and clustering. In the proposed algorithm, problems of cluster head selection and data transmission are addressed. For determining, an optimum location of cluster head a candidate weight based on the residual energy and degree of a node is fixed. For reducing energy consumption, multi-hop inter-cluster data transmission is used, with relay nodes being selected based on a relay function that is defined by parameters like residual energy, distance between the nodes and the number of member nodes in a cluster.

Qin, D. *et al.* (2018) proposed a Data collection and Load balancing Algorithm in WSN with energy hotspot issue under consideration. Heavy load on cluster heads near base station leads to early death of these nodes results in a communication blockade. A concept of multiple parallel paths for inter-cluster communication is proposed. Although the total energy consumption of the proposed algorithm is slightly higher, the average energy consumption of each node is reduced, increasing the network lifetime by avoiding the premature death of overburdened nodes.

Khoulalene, N. and Djamil, L. B. (2018) have proposed an energy efficient routing protocol for WSNs based on clustering and load balancing. In order to make efficient use of energy and other recourses an amalgam of improved version of Gossiping Protocol with dual techniques of Clustering and Load Balancing protocol has been used. Simulation results have proven IGP-C to be efficient in terms of energy and reduced the transmission delays. Several metrics like residual energy, storage and processing capabilities, degree of node and distance to the base station are used in cluster head selection and data routing.

Gherbi, C., Aliouat, Z. and Benmohammed, M. (2019) proposed an energy efficient algorithm based on two valuable techniques of clustering and load balancing to optimize the network resources in order to extend network lifetime. Cluster heads are optimally selected and distributed over the network keeping the intra-cluster communication at minimum as a means to reduce the energy consumption. In addition, nodes are considered heterogeneous in terms of energy with cluster heads being more resourceful.

Tripathi, Y., Prakash, A., and Tripathi, R. (2019) have proposed a cooperative Load balancing routing protocol for WSN. In order to achieve energy efficiency with quality of service like packet reception ratio two types of data transmission is involved; direct data and relay based transmission. At the initial phase shortest and optimal route is chosen based on hop count (number of hops required by data from source to sink) and packet reception ratio, and during transmission if the energy of an intermediate node goes below a threshold then relay based transmission is used by choosing a relay node for inter-cluster communication.

Ennaciri, A., Erritali, M. and Bengourram, J. (2019) proposed a Load Balancing Protocol (EESAA) to improve Quality of Service in WSNs. It is a clustering based routing protocol to improve the lifetime of the network along with packet delivery ration and stability period. The

proposed routing protocol is actually an improvement of LEACH with sleep/awake mechanism in place.

Kumaratharan, V. R. N. (2020) Multi-hop Optimized Routing Algorithm and Load Balanced Fuzzy Clustering A three Tier Multi-hop Optimized Routing Technique based on distributed approach is proposed. In that protocol fuzzy inference is used to select the cluster heads.

Khediri, S. El *et al.* (2020) proposed a modified form of LEACH(low energy adaptive clustering hierarchy) protocol, Multi-weight LEACH(MW-LEACH) for cluster head selection in wireless sensor networks based on multiple factors like residual energy, distance between nodes, and number of members in a cluster. Uniform clustering and fair distribution of cluster heads across the entire network is used to achieve energy optimization. Simulation have shown that the protocol is efficient in terms of Packet delivery ratio, Network lifetime, Latency and throughput in comparison to other existing protocols.

Khan, M. K. *et al.* (2021) presented an extensive review of different hierarchical routing protocols and their performance parameters and functional aspects. It has highlighted different issues and challenges in existing routing protocols, in order to pay way for future research in designing of energy efficient routing protocols in WSNs.

Maratha, P and Gupta, K. (2021) proposed a Load Balancing Energy Efficient Routing Scheme for Wireless Sensor Networks. The work involves selection of the best possible relay node based on the load on sensor node for reducing the energy consumption. In multi-hop data transmission, the next hop relay node is selected in the non-increasing order of the load on the nodes.

Sahoo, B. M., Pandey, H. M. and Amgoth, T. (2021) have proposed a hybrid algorithm GAPSO-H based on two separate algorithms, Genetic Algorithm and Particle Swarm Optimization for addressing the issues of cluster head selection and data transmission with mobile sink. Genetic algorithm is used for selection of optimal cluster head using a fitness function dealing with various parameters like residual energy, degree of node, energy consumption rate, etc. After determining the fitness function PSO is used to determine the best route for data transmission by optimizing the value of fitness function. Efficiency of the algorithm is determined in terms of various performance parameters like network stability and lifetime, number of dead nodes, remaining energy, etc.

Hassan, A., Anter, A. and Kayed, M. (2021) have proposed an algorithm to extend the lifetime of the network by distributing the load on the cluster head among other members in the cluster with no re-clustering i.e. clustering and selection of cluster head happens only once. Two techniques have been used for solving the optimization problem; Quantum based Particle swarm optimization and Game Theory to determine the optimal vale of load that each nodes needs to share. A wireless Power Transfer mechanism is also discussed for transfer of energy from member nodes to the cluster head depending upon the residual energy of each node.

2.2. GAPS IN RESEARCH

After going through the literature following gaps are identified:

1. Existing algorithms mostly perform intra-cluster load balancing without considering the entire network.

2. Most of the clustering techniques either select the cluster head randomly or based on the centralized approaches.

3. Either single-hop communication is used by the cluster heads or the relay nodes when selected are based on probabilistic approaches.

4. Most of the existing algorithms consider only energy as cost function for relay node selection without taking into account the load on cluster heads.

5. In addition to the above, in the existing algorithms the cluster size is fixed irrespective of the load and distance from the base station that leads to energy hole problems.

3. DESCRIPTION OF TOPIC

Clustering involves grouping of sensor network into small groups called clusters; each having an individual head called cluster head and several cluster members. Clustering of sensor nodes in a network is important for solving various problems like scalability, energy efficiency and lifetime in wireless sensor networks (Mamalis *et al.* 2009). Load balancing is a method to fairly distribute the load in a network in order to prevent the premature death of some overburdened nodes. Even after clustering, some nodes (cluster heads, relay nodes and nodes close to base station) with heavy load suffer with a quick energy exhaustion leading to reduced network stability. Load

balancing improves the lifetime of the network, as all the nodes will have similar energy consumption rate based on the distributed traffic (Mishra and Paul 2017).

3.1. Clustering:

Based on network topology a network can be classified as flat or hierarchical cluster based networks. In flat networks, every sensor node in the network performs the similar function and is connected with each other using multi-hop communication (Zeb *et al.* 2016). It involves flooding technique to deliver a message from source to destination wherein the entire network is involved. Such type of communication technique is not feasible for large networks as it involves higher energy consumption, data redundancy, high delays and unequal consumption of energy of sensor nodes due to varying load.

Whereas in cluster-based networks, a network is divided into small groups each consisting of a cluster head and several cluster members. In cluster-based networks communication takes place either as intra-cluster or inter-cluster communication over short distances as compared with the flat networks.

3.1.1. Components of a cluster:

Clustering involves logical organization of a sensor network into small and easily manageable groups each having a cluster head (CH) and several members (Mamalis *et al.* 2009).

i. Cluster head:

Each cluster has a local leader or coordinator called a cluster head. Cluster head performs various functions such as collection of data from its member nodes, aggregation of collected data and forwarding that aggregated data to the base station.

ii. Cluster members:

In addition to the cluster head, a cluster has several members called member nodes. Member nodes are mainly responsible for sensing of information for the region of interest. These member nodes forward all the information to the cluster head using intra-cluster communication.

iii. Gateway node:

Gateway nodes are responsible for communication between different cluster heads.

3.1.2. Performance metrics of cluster based WSN's:

In order to design an efficient clustering technique several factors of a wireless sensor network are taken into consideration. An algorithm is designed as per requirements arising from these parameters. Some of the parameters are discussed as under:

i. **Node Type:** In a WSN sensor node (CH or MN) can be either static or dynamic in nature. A static or stationery node has a fixed position in the cluster whereas a dynamic node changes its position w.r.t other nodes. In case of dynamic nodes a challenging problem is retention of cluster for a long time and a subsequent packet loss.

ii. **Network Type:** In WSN, cluster formation follows two approaches; distributed and centralized. In distributed approach is of probabilistic nature wherein a node can become either cluster head or member node based on certain parameters calculated at node level. Whereas, in centralized approach entire network information is required at the base station for cluster formation and selection of cluster heads (Zeb *et al.* 2016).

iii. **Energy Efficient Cluster:** Clustering should be efficient in terms of energy consumption as wireless sensor nodes have an energy source with limited capacity (small batteries).

iv. **Cluster Communication**.

In a cluster-based network, communication can take place either as intra-cluster or inter-cluster communication.

a. Intra-cluster Communication: Communication taking place within each cluster is termed as intra-cluster communication. It can be either single-hop or multi-hop. In single hop intra-cluster communication, all member nodes send their sensed data directly to the cluster head whereas in multi-hop intra-cluster communication data passes through intermediate nodes.

Single-hop intra-cluster performs efficiently as compared to multi-hop intra-cluster communication in terms of energy conservation.

b. Inter-cluster Communication: Communication taking place among various clusters is called inter-cluster communication. Either a cluster head can forward the data to the base station directly in a single hop or it can be forwarded to other relay nodes for further transmission resulting in multi-hop communication. In case of larger networks, multi-hop inter-cluster communication performs better in comparison to single-hop inter-cluster communication.

v. Homogenous or heterogeneous cluster:

A cluster having all the nodes similar in terms of energy and other hardware recourses is called a homogenous cluster. In a homogenous cluster sensor node can act as cluster head or cluster member. Whereas, a cluster in which the cluster heads are predefined and are equipped with higher energy and more powerful communicational and computation recourses is called a heterogeneous cluster.

vi. Fixed or adaptive cluster:

In terms of the size, a cluster can be either of fixed or adaptive nature. Clustering in which every cluster has a fixed number of member nodes is called a fixed cluster technique. In adaptive or dynamic clustering the size of the cluster varies on the bases of factors like distance from the base station and traffic load on a particular cluster head. In terms of energy consumption and stability of the network adaptive clustering is considered to be more efficient.

3.1.3. Advantages of Clustering in WSN's:

1. Clustering technique can simplify the management of nodes as the network is divided into relatively small manageable groups each having a local coordinator.
2. Clustering can reduce the energy consumption rate owing to lesser number of transmission and reduction in the distance over which a message needs to be transmitted. Hence improving the network lifetime.
3. It reduces the data redundancy ad the cluster heads perform the data aggregation before further transmission of data.
4. Increases scalability and robustness of the network.

3.1.4. Challenges in clustering:

While clustering has several advantages there are several factors that needs to be considered while designing a clustering algorithm.

1. Energy overhead during cluster formation.
2. Cost of clustering.
3. Selection of optimal cluster head.
4. Selection of relay nodes during multi-hop inter-cluster communication.
5. Residue energy of the nodes after each round.
6. Size of the cluster.
7. After each round, re-clustering should be done efficiently.
8. Dying of cluster head closed to the base station more quickly because of high data load (dead lock).

3.2. Load Balancing in Wireless sensor networks:

After cluster formation many of the problems stated above need to be addressed. Load balancing is a technique that is used to solve the energy optimization problem of the sensor nodes for extending the network lifetime. Load balancing is used to address the issues of cluster head selection, dead lock, cluster size, selection of relay nodes, stability, aggregation and transmission of data, intra and inter-cluster communication, etc. By applying load balancing, the lifetime of the network depends upon the life of all the nodes in the network as issue of unequal consumption of energy is addressed. In the selection of cluster head load balancing is achieved by considering certain weight value based on various parameters like initial energy of the sensor nodes, residual energy of nodes, distance from the base station, number of neighbors, fairly distribution of cluster heads (Wajgi 2012).

4. OBJECTIVES OF RESEARCH

4.1. Problem Formulation

As seen in section 1.2 wireless sensor networks have very diverse applications and this gives rise to certain unique challenges in the realization of an efficient wireless sensor network. Among these various challenges three major constraints faced by the WSN's are Energy, hardware resources and communication bandwidth constraints. Energy is directly concerned with the

lifetime of a WSN. Lifetime is the duration from the deployment of the sensor nodes in an operational environment until the first node dies or become inactive. Most of the sensor nodes are battery powered and it is almost impossible to replace those batteries once these nodes are deployed in the intended regions (massive and random deployment in harsh and hostile environments).

It is always desired to prolong the life of a WSN or it should at least sustain until the completion of the operation. Thus, energy in a wireless sensor network is strictly constrained. The energy consumption of a sensor node is a wireless sensor network is mainly dependent on the factors like, number of rounds, sensing (whether continuous or event driven), topology (flat or hierarchical), distance from the sink and activity schedule (Figure 3a). Energy consumption in a WSN is mainly due to communication, sensing and computing sub-systems (Engmann *et al.* 2018).

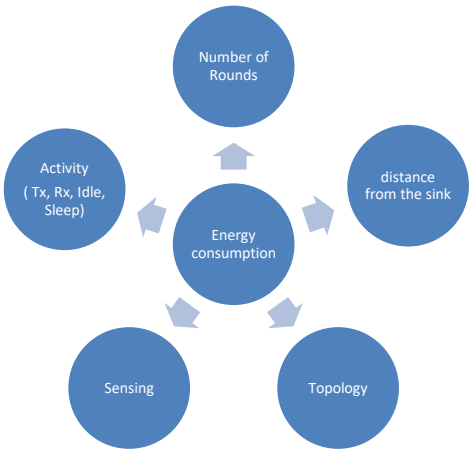

Figure 3a

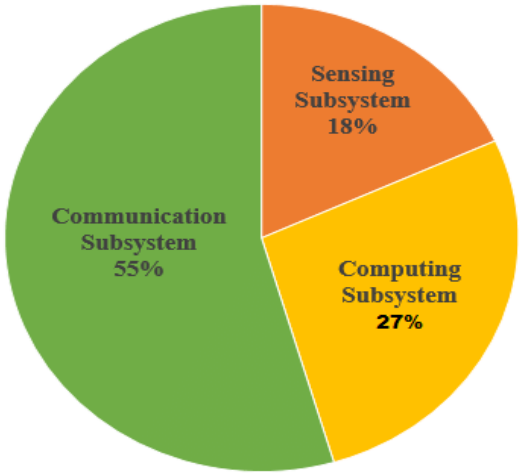

Figure 3b

Fig 3b (Nawir *et al.* 2018) shows the portion of energy consumed by each subsystem. As seen from the fig communication takes most of the available energy. The energy consumption of a node directly depends on the distance from the sink and the load on that node. Larger the distance and higher the load, greater is the energy consumption and subsequently more quickly the energy of the sensor node is exhausted. Network topology is also determinate in the lifetime of the WSN. Therefore, to extend the network lifetime along with maintaining the Quality of service (QoS) in a network, an energy efficient way of communication that will include networking among sensor nodes and routing of the sensed information, is needed. Load

balancing with clustering is a technique to reduce the consumption of energy thereby extending the network lifetime.

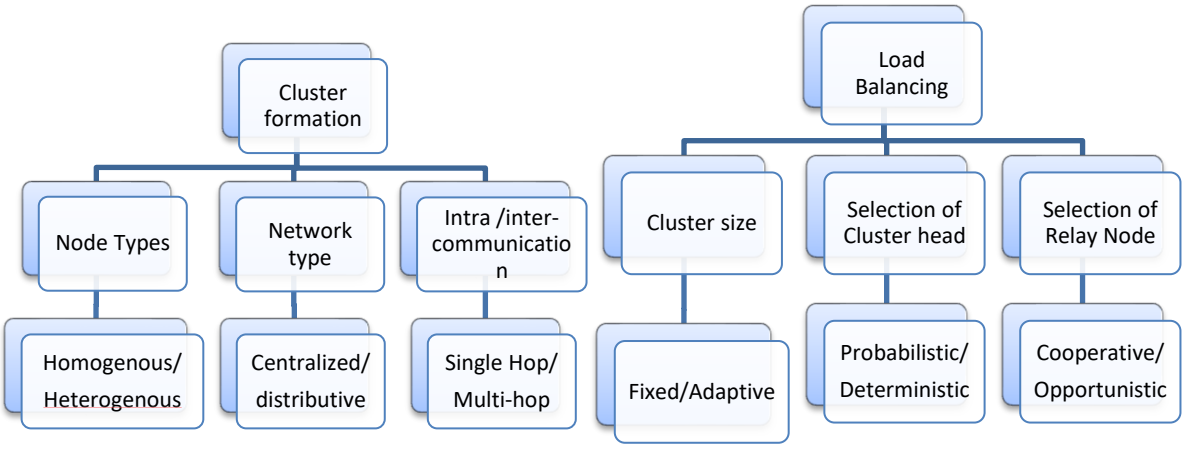

Figure 4: Characteristic metrics in Load Balancing with Clustering

4.2. Objectives of Research

1. To perform a literature survey of the existing algorithms related to clustering, load balancing, Quality of service (QoS) and lifetime in wireless sensor networks.
2. To compare these existing algorithms and finding limitations.
3. To design/modify Clustering and Load Balancing algorithms that will enhance the energy efficiency and prolong the network lifetime with QoS in Wireless Sensor Networks.
4. To implement the proposed clustering and Load Balancing algorithms using simulators like MATLAB, NS2, etc.
5. To compare the experimental results of the implemented algorithms with the existing algorithms.

5. METHODOLOGY

After going through the literature and identifying the gaps new/modified algorithms and protocols will be designed to fulfill the intended objectives.

The Research Methodology will include the following phases:

Phase I: Expression formulation.

In this phase expression for different parameters like lifetime, residual energy, distance between the nodes, Cluster size, Number of clusters and the Number of neighbors will be formulated. Some of these can be combined together for a fitness function.

Phase II: Defining Algorithms

Energy efficiency can be achieved by adopting different strategies based on classical, optimization or machine learning techniques at various steps of Clustering. These techniques can be applied either individually or as in a hybrid form.

Stages where these techniques will be adopted:

1. Selection of Cluster Head (CH).
2. Cluster formation
3. Transmission of Data.

New or modified algorithms will be evaluated at above mentioned stages.

Phase III: Simulation

In this phase, an extensive simulation will be carried out for comparing the performance of the proposed algorithm and protocol with the existing techniques with the help of simulation Software MATLAB. The comparison will be based on the various performance metrics like Network lifetime, Packet Reception Ratio(PRR), latency, Number of Rounds, Stability(Time till first node dies), Throughput, Average energy consumed.

6. EXPECTED OUTCOMES

Wireless sensor networks are strictly constrained in terms of available energy. Therefore, in order to improve the lifetime of the network an energy efficient algorithm is needed along with maintaining the Quality of services.

To overcome the limitations in the existing algorithms, modified/new algorithms proposed will be energy efficient with proper load balancing across the network. It is supposed to improve the network lifetime along with enhancement in the performance metrics like packet reception ratio, throughput, end-to-end delay, number of alive and dead nodes, average energy consumption, etc. In addition, the proposed clustering algorithm will increase the network scalability with reduced data redundancy.

7. PROPOSED TIME PLAN

Research plan	Sem 1 Dec 20	Sem 2 Jun 21	Sem 3 Dec 21	Sem 4 Jun 22	Sem 5 Dec 22	Sem 6 Jun 23	Sem 7 Dec 23
Course work							
Literature survey							
Review paper based on Literature Survey							
Data Collection							
Data study							
Data Interpretation							
Compilation of Work: Thesis Writing							
Thesis Submission							

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